Here we are at the essential point. If a wireless station were sending daily weather telegrams from one or preferably from a greater number of Greenland meteorological stations, then a cyclone would not often be able to cross the line from Greenland to the British Islands unobserved. It would be possible at an early phase to carry through the classification, which now to a great extent takes place after the cyclones have raged off the coast of Norway. If the forecast can be based upon a reliable classification made at a sufficiently early phase, then one ought not often to be surprised by a devastating storm. For middle Europe, from Denmark to the south, the case will be about this: The cyclones *A*, *B*, and *C* will usually not give occasion for any anxiety. From a distance they will have influence upon the daily weather and be of importance for the forecasts, but they will rarely cause violent storms. But when the *D* cyclone comes, then the meteorologist must be alert.

A special reason why the *D* cyclone and those following often come as surprises is that they are often formed relatively close to the European coast, even within the European region. However, if the meteorologist has had opportunity to study the preceding *A*, *B*, and *C* cyclones closely, then he already at an early phase will know when and where a *D* cyclone may be formed. He further knows that the *D* cyclone in the first 24 hours will not develop any dangerous violence or move with unexpected velocity. But on the second or third day the wind velocities in the cyclone may reach the violence of a hurricane, as was the case with the October cyclone crossing Denmark. Also the tendencies in this respect are evident from the conditions under which the cyclone is formed. In the same way it will be possible at an early phase to decide whether an *E* cyclone will form after the *D* cyclone, and so on.

Therefore, in order to be able from the very beginning to follow this play of the cyclones, which determine the weather of Europe, a wireless station at the south point of Greenland will be of the highest importance. This station will be of great value for Denmark, and a fine gift to the whole of Europe. For the countries with the most exposed positions, Iceland, the British Islands, and Norway, the importance of this station can not be overestimated.

It is evident from the efforts these countries have made to obtain protection that great economic interests are dependant upon reliable weather forecasts. Wireless weather telegrams are now sent from English, Swedish, and Norwegian ships crossing the Atlantic Ocean, and French ships are expected soon to begin. This is a good support, which, however, can never replace a station on Greenland, because the routes of the steamships are so far south that the observations from the ships do not render the full view of the situation. Further, Norway has in this year experimentally established a weather station with wireless on the most inhospitable of all polar islands, Yan Mayen. This station has only been operated a few months, but has already proved so useful that there will hardly be thought of abandoning it. However, weather telegrams from Greenland would be of still higher importance, which is made evident by the following example:

During the period December 1, 1919, to March 15, 1920, between 70 and 80 storms occurred at that part of the Norwegian coast for which the forecasts at that time were issued from Bergen. Not less than 22 of these storms were either not predicted or the issued warnings came too late to be effective. I must add, that these unwarned storms on an average were the most violent. But only six came from the direction in which the station on Yan Mayen now makes us feel safe. The other 16 came the common way from the west, where only telegrams from Greenland can render corresponding safety.

Let me also mention that in addition to these unwarned storms, five or six cases of false alarms occurred. These cases are regarded as the worst mistakes of the forecasters, because they shake the confidence of the public in the storm warnings. But they appear inevitably, because the forecaster, one time after another, has to take a chance and send out a storm warning based upon the first uncertain indications. He knows that if he would wait for the next observation, then the warning would come too late. This is the situation of the forecaster in this and in other countries: on the one hand, the responsibility for great economic values and human life—on the other hand, the responsibility, not to mention the laughter that accompanies the false alarm. What makes the situation so awkward is that the forecaster usually has to form his opinions of the coming weather on an absolutely insufficient foundation. When work of this kind is demanded, then the foundation for such highly responsible decisions must be made as good as possible.

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DISCUSSION.

By A. J. HENRY.

The observation by Dr. Bjerknes regarding the occurrence of cyclones in well-developed groups must refer mainly to cyclones which have their origin to the westward of and pass over Northwestern Europe. It is important to emphasize this distinction, otherwise the impression may be created and perpetuated that the occurrence of cyclones in groups is a characteristic which belongs to all cyclones of the Northern Hemisphere.

Seasonal causes seem to control the place in latitude at which cyclones pass onto the Continent of North America. Cyclones of the winter enter the United States from the Pacific most frequently along the coast north of latitude 45°.

South of that latitude the occurrence of winter cyclones is much less frequent; indeed, several years may pass without the occurrence of a single cyclone south of San Francisco, hence we incline to the belief that the rule enumerated by Dr. Bjerknes does not apply to the Pacific coast storms. Bowie and Weightman [1] in their discussion of the different types of cyclones explain the movement in low latitudes as being due to high pressure in Alaska and the western Canadian Provinces. They say, in discussing storms of the Northern Pacific type:

> Storms of this class usually make their appearance on the Washington and Oregon coasts and thence move eastward in widely different courses. There are two, however, that are often followed—one due east along the northern border and the other southeastward from the North Pacific States to the Southern Plains States and at times quite to the Gulf coast and thence eastward or northeastward. During the time of appearance of lows of this type the Aleutian low is well defined, but somewhat south of its normal position, and the pressure is above normal over the interior of Alaska. The Alberta type of disturbance is no longer in evidence and in its stead the pressure is unusally high in that region, the Northern Plains States, and in the

[1] Storms of the United States, MO. WEATHER REV. SUPPLEMENT NO. 1, Washington, 1914.

region of the Great Lakes. A feature of the North Pacific storms is that they do not usually occur singly—that is, when this type appears the first storm will be followed by others of the same type. Frequently this storm prevails with great intensity on the North Pacific coast, but, unless it takes the southeastern track, it loses its marked intensity in crossing the Rocky Mountains.

The total number of cyclones charted each year ranges from 90 to 150 with an average of close to 130 per annum. No attempt has been made to class these storms in the order of their severity, but it is a common observation on the part of the forecasters that the most severe storms almost invariably move poleward rather than from west to east. As a rule storms advancing from the West lack the severity manifested by northeastward-moving storms. Cyclones which move across the United States and southern Canada occasionally tend to form more or less well-defined groups, members of which pursue substantially the same path as, for example, in February and March, 1904, when the Alberta type apparently changed to the North Pacific type, the latter continuing through March. This series affords an excellent example of the tendency of cyclones to move in groups. The table below presents the data of origin and movement chronologically beginning February 1. The data are taken from the MONTHLY WEATHER REVIEW.

TABLE 1.—*Origin of cyclones of February and March, 1904, months when the movement was in fairly well-defined paths.*

[See chart II of the REVIEW for the months named.]

Date.	Apparent origin.		Date.	Apparent origin.	
	North latitude.	West longitude.		North latitude.	West longitude.
1904.	°	°	1904—Continued.	°	°
Jan. 31	51	114	Feb. 27	38	105
Feb. 4	48	125	Mar. 1	48	125
7	43	113	3	33	115
11	47	125	8	51	120
12	53	103	10	48	125
15	47	125	14	45	125
19	51	104	17	48	125
20	29	94	19	48	125
22	42	107	22	48	125
22	53	125	28	42	108
23	47	122	Apr. 3	51	120
26	52	120	5	49	125

By E. H. BOWIE.

In applying the principles outlined by Dr. Bjerknes one should understand that they specifically apply to that part of the North Atlantic Ocean east and north of a line drawn from the south point of Greenland to the British Isles; also that his reference to "depressions born to the south or west of this line," does not mean that they actually had their origin immediately south or west of this line, but that some of them may have formed over the ocean and many others no doubt first crossed the American Continent. Also we must understand that the *A, B, C, D* storms may be of the same intensity, but since the *A* and *B* storms cross the longitude of Norway in high latitudes, that country does not become involved in the full intensity of these two types; later, *C* and *D* storms come along, moving in lower latitudes, and sweep over central and southern Norway and the full intensity of them is there experienced.

There is reason to believe that a grouping of cyclones similar to those described by Dr. Bjerknes is frequently noted on the weather charts of the United States and Canada, but the groups do not follow a hard and fast rule; it is a strong tendency rather than an inflexible law. This fact was brought out in the paper on the "Storms of the United States and their average movement," by by Bowie and Weightman, wherein it was stated:

The variations in position and magnitude of the elongated subpermanent area of low pressure that normally extends from southeastern Alaska to Kamchatka have a decided influence on the character of and courses followed by storms (cyclones) that cross the United States. If this Aleutian LOW is north of its normal position, LOWS will move far south of their normal tracks and stormy weather with great alternations in temperature will occur over the United States. The paths of storms which cross the United States shift (north and south) with the position of the Aleutian LOW. For example, when after a period of indifferent pressure (compared with the normal) within the Aleutian area the pressure in this region begins to fall, a LOW will appear within 36 hours north of Montana; as the Aleutian LOW deepens, LOWS will follow each other in rapid succession along the northern border until the pressure begins to rise north of the Aleutian area and it (the Aleutian LOW) moves south of its normal position, when the tracks of LOWS in the United States will shift to lower latitudes. Finally, when the Aleutian LOW reaches its southernmost position, LOWS crossing the United States will make their first appearance in the southern Plateau region or over the Gulf of Mexico.

Also in a paper on "The Planetary System of Convection," by W. R. Blair, in the MONTHLY WEATHER REVIEW, April, 1916, there will be found on page 194 the following:

Some years ago Mr. E. H. Bowie called the writer's attention to the fact that the low-pressure areas enter and cross the United States in *series*. The first low-pressure area in such a series will enter the country well to the north and pursue a course eastward over the Northern States, the second enters somewhat farther south, and so on. The last low-pressure area of the series may enter the extreme Southwest and pass along the Gulf and Atlantic coasts, although the series do not always carry as far south as this. The series follow each other in close succession. The relation between these series of low-pressure areas and the general meridional movement of the atmosphere seems to be quite direct.

There can be no question that there is a similarity between the progressive southward movement of storm tracks in series over the United States and western Europe, but, as stated before, the sequences do not follow any hard and fast rule. Also, it is not infrequently noted that at times LOWS crossing the United States will group themselves by type—that is, there will be several successive LOWS of the Alberta type or several of the Colorado type. The Alberta type continues when the Aleutian low-pressure system is normal or slightly north of normal in position and the departures from normal pressures therein are of no great consequence.

Figure 1 illustrates three series of LOWS that crossed the United States during March, 1916. The similarity of these series to those referred to by Dr. Bjerknes is apparent.

The importance of radioed weather reports from Greenland to the meteorological services of Europe can not be too strongly urged. Reports from that continent will link the areas of meteorological observation of North America and Europe, bridge the Atlantic, and give the forecaster of Europe an outlook as to coming changes comparable with that now had by the forecaster at Washington. Moreover, many times such reports would be of great value in weather forecasting in the United States, for it is the writer's belief that the abnormal retardations in the eastward movement of high and low pressure areas across the United States are brought about by abnormal conditions over Greenland.

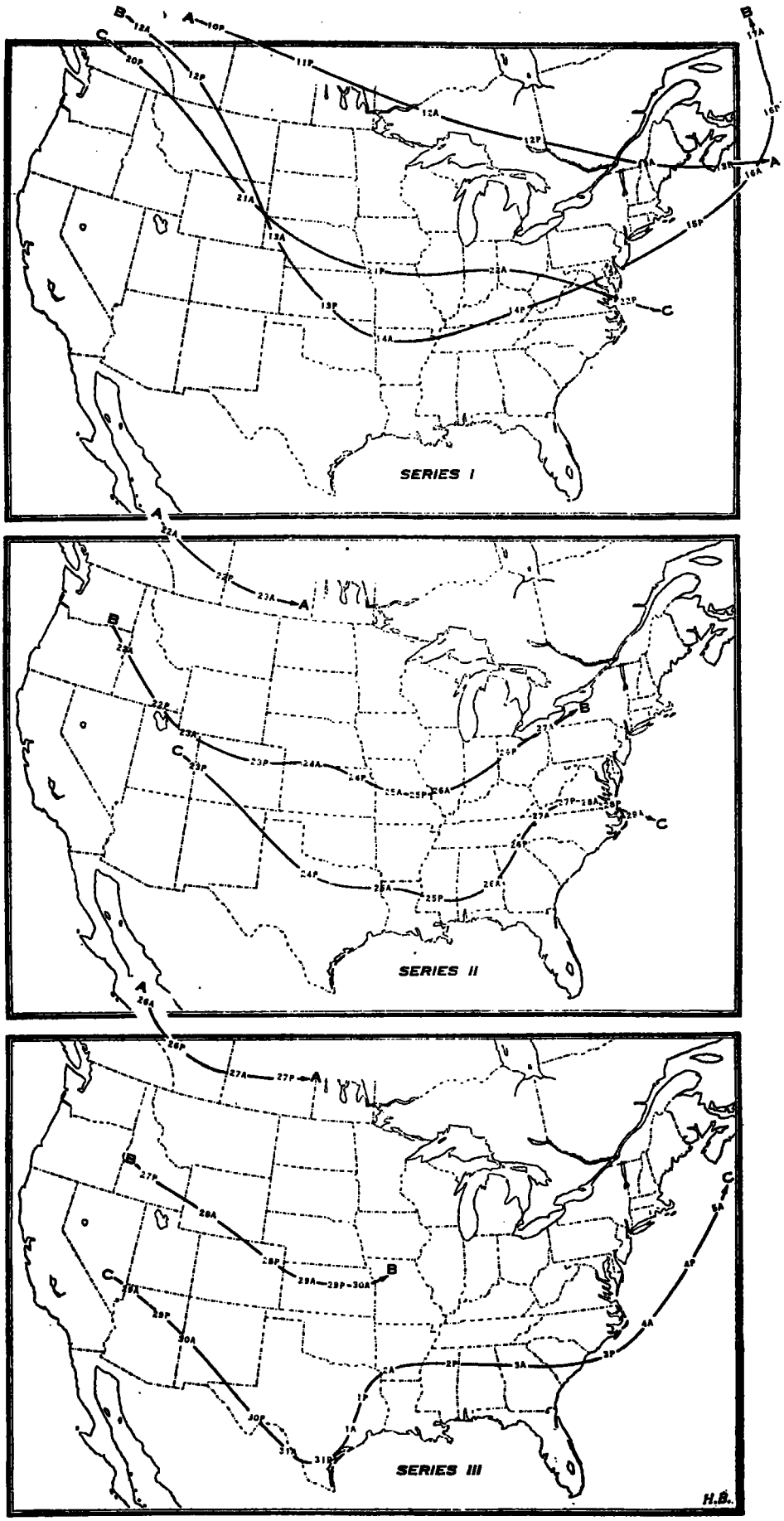

FIG. 1.—Three series of low-pressure groups, March, 1916, similar to those described by Dr. Bjerknes.